Modulating Retro-reflectors for Free Space Optical Data Transfer Using Multiple Quantum Well Technology

G. Charmaine Gilbreath, William S. Rabinovich, T.J. Meehan, M.J. Vilcheck, R. Mahon, E. Oh, M. Stell, I. Sokolsky, J.A. Vasquez, K. Cochrell, K.C. Goins, D.S. Katzer, P. Goetz, and S. Mozersky

US Naval Research Laboratory, Washington, DC 20375

http://mrr.nrl.navy.mil

- **Objective:**

  To transfer data, optically, between a flyer and a ground station, or large platform, without the need to fly a laser or pointer/tracker.

- **Approach:**

  Combines an optical retro-reflector and a multiple quantum well (MQW) shutter to modulate a laser beam that is incident on the flyer (Fig. 1).

- **Advantages:**
  - The MQW modulator is lightweight, compact, and it requires little power (~50 mW per shutter);
  - Data rates of 10 Mbps and higher may be supported;
  - No pointing and tracking is required on the flyer when payload is configured as an array;
  - The communication link is jam resistant and covert;
  - Technique provides significant frequency allocation relief over radio frequency carriers.

- **Typical applications:**
  - Air or Space-to-Covert Ground Sensor (Fig. 2)
    Remote interrogation of sensors
  - UAV to Ground (Fig. 3)
    Surveillance from an unpiloted airborne vehicle
  - Space to Space (Fig. 4)
    Configuration Management and MicroSat Communications
  - Ground-to-Space
    Laser Communication and Surveillance via satellite

- **NRL Ground to UAV Demonstration**
  - UAV
    - A small (1-1/2 meter long) helicopter carries a modulating retro (Fig. 5)
    - The UAV is illuminated by an unmodulated laser beam from the ground station.
    - A bit stream is converted to a digital voltage signal which modulates the incoming light beam by switching the quantum well shutter on and off.
    - When the shutter is open the retro-reflector automatically sends the light beam back to the ground station with no need for pointing/tracking.
  - Ground station
    - A motorized gimbal controlled by a tracking camera holds a laser diode, a 5 cm diameter telescope and a photodetector.
    - The ground station tracks the UAV and illuminates it with the laser.
    - The ground station also receives the retro-reflected signal. Fig. 6 shows a 5 Mbps data stream; more recent tests have demonstrated a video link in the laboratory at 6 Mbps with 30 frames/sec in eye-safe laser intensity.
    - Obtained video-in-flight up to 4mbps with 30 frames/sec (Fig. 7)
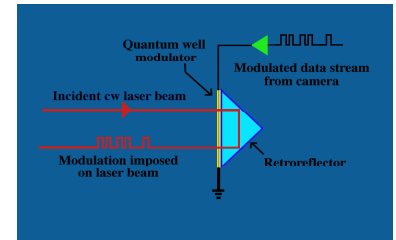

Fig. 1

Fig. 2

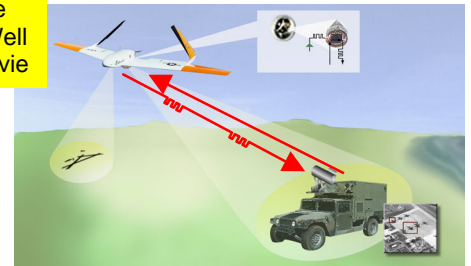Click the little black box to the left to view the Multiple Quantum Well Retro Modulator movie
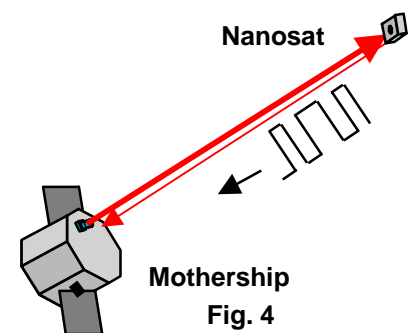

Fig. 3

Nanosat

Mothership
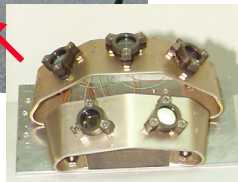**Fig. 4**

Fig. 5

Fig. 6

Fig. 7